

ABRASIVES, MANUFACTURED

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This report includes information on the following abrasives manufactured in the United States: aluminum-zirconium oxide, boron carbide, fused aluminum oxide, metallic shot and grit, and silicon carbide. In some cases, United States production data were combined with Canadian output to avoid disclosing company proprietary data and still provide useful data on the overall Canadian-United States market. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using the unrounded data.

In 2004, estimated United States and Canadian combined production of regular-grade fused aluminum oxide was 20,000 metric tons (t) with a value estimated at \$6.5 million. The U.S. apparent consumption of fused aluminum oxide was estimated at \$57 million. U.S. silicon carbide production was an estimated 35,000 t with an estimated value of \$21.5 million. The U.S. apparent consumption of silicon carbide was estimated to be more than \$124 million. U.S. production of metallic abrasives was 194,000 t valued at \$92 million. U.S. shipment of metallic abrasives sold or used was 201,000 t, with a value of \$97.4 million.

Abrasives play an important role in the fashioning and finishing of many products with a wide range of end uses. Abrasives are natural or manufactured substances that are used to abrade, clean, etch, grind, polish, scour, or otherwise remove solid material by rubbing action (as in a grinding wheel) or impact (as in pressure blasting). The most important physical properties for abrasives are character of fracture (cleavage), friability, grain shape and size, hardness (scratch hardness), purity (uniformity), and toughness (rigidity). Additional considerations include availability, bonding characteristics, cost, and thermal stability. Manufactured abrasives are made from metals or minerals by heating or chemically treating them to enhance or give them abrasive properties. No single property is paramount for any use (Wellborn, 1996, p. 31, 43).

Manufactured abrasives generally dominate high-grade abrasive markets as opposed to natural abrasives because they have superior physical properties, more uniform quality, and can be tailored to meet users' needs. Consequently, manufactured abrasives typically are characterized by premium prices relative to natural abrasive minerals. Even though manufactured abrasives are usually more expensive, their durability and efficiency have proven to be more cost effective. They are preferred in many industrial applications, such as metal finishing, cutting, and polishing. In the United States, large volumes of abrasives also are used in cutting and finishing wallboard and timber. The abrasives market is mature, and the use of various manufactured abrasive materials is fairly well defined by application (Kendall, 2001, p. 55).

Fused Aluminum Oxide

Legislation and Government Programs.—As of January 1, 2005, the National Defense Stockpile (NDS) maintained by the U.S. Department of Defense (DOD) contained 8,290 t of fused aluminum oxide abrasive grain valued at about \$3.1 million. During 2004, the DOD reported sales of 1,810 t of NDS aluminum oxide abrasive grain for about \$606,000. All the NDS crude fused aluminum oxide was sold during 2000. Under Federal legislation authorizing the disposal of all NDS aluminum oxide, the DOD planned to continue such sales until all the stockpiled aluminum oxide was sold (Janet Rollins, market analyst, Defense National Stockpile Center, oral commun., February 14, 2005).

Production.—Production data for regular and high-purity fused aluminum oxide in this report were obtained by the U.S. Geological Survey (USGS) from producers in Canada and the United States. The data were collected from two companies that operated three plants and represented the entire Canadian and United States fused aluminum oxide industry (table 1). Washington Mills Electro Minerals Corp. operated fused aluminum oxide plants in Canada and the United States. Data from the two countries were combined to avoid disclosing company proprietary data.

Estimated production of regular-grade fused aluminum oxide in 2004 was 20,000 t with an estimated value of \$6.5 million. This was about the same weight and about 16% more in value compared with 2003 regular-grade fused aluminum oxide production (table 2). Reporting on the output of high-purity fused aluminum oxide has been discontinued to avoid disclosing company proprietary data.

Consumption.—In all sections of this report, consumption is defined as apparent consumption, which is domestic production plus imports minus exports plus adjustments for Government and industry stock changes. Abrasive-grade fused aluminum oxide has many end uses. Specific applications in 2004 included antislip additives, bonded abrasives (such as abrasive grains that are made to adhere to each other and then are pressed or molded into abrasive tools), buffing/polishing compounds, coated abrasives (such as abrasive grains glued to a backing of paper or cloth), dry or wet blasting media, and tumbling media. Fused aluminum oxide in a micropowder form was used for industrial and electronic applications that require fine surface finishing. Fused aluminum oxide does not face any significant substitution threats at present as it is generally a very cost-effective abrasive. The total value of fused aluminum oxide abrasive grain consumed in the United States was estimated to be \$57 million in 2004.

Prices.—The USGS canvassed fused aluminum oxide producers to determine the total value of their production for the year. The survey indicated that the average unit value of regular fused aluminum oxide produced in Canada during 2004 was \$323 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was \$544 per ton at the point of production. Prices of abrasive grain produced from these materials and sold to consumers were significantly higher. The average price of NDS fused aluminum oxide grain sold in 2004 was \$335 per ton.

Average unit values of fused aluminum oxide traded by the United States in 2004 are based on U.S. Census Bureau customs value data. The average value for U.S. exports of fused aluminum oxide during the year was about \$2,955 per ton. Average unit values of crude fused aluminum oxide imports during the year ranged from \$244 per ton (China) to \$417 per ton (Venezuela). Values of fused aluminum oxide grain imports ranged from \$360 per ton (Venezuela) to \$2,960 per ton (United Kingdom).

Foreign Trade.—Compared with the previous year, 2004 crude fused aluminum oxide exports increased by 18% to 13,900 t, and the value of those exports increased by 19% to \$41.2 million (table 6). Of the exports shipped to 31 countries, 72% went to Canada, Germany, and Mexico.

During 2004, imports of crude fused aluminum oxide were received from 13 countries and increased by 47% to 181,000 t valued at \$50.3 million compared with those of 2003, and imports of ground and refined fused aluminum oxide were received from 22 countries and increased by 26% to 51,200 t valued at \$47.8 million (table 5). Some of the imported crude fused aluminum oxide was refractory-grade material. China, Canada, and Venezuela supplied 80%, 11%, and 8%, respectively, of the crude imports. Compared with 2003, crude imports from China increased by 62%, while imports from Canada and Venezuela increased only by 5% and 8%, respectively. Germany, Brazil, Austria, and Canada provided 20%, 18%, 13%, and 10%, respectively, of the ground and refined material.

Silicon Carbide

Legislation and Government Programs.—The DOD completed sales of its stockpiled silicon carbide in 1999 (Janet Rollins, market analyst, Defense National Stockpile Center, oral commun., February 14, 2005). The DOD was not expected to replenish the silicon carbide stockpile.

Production.—One company produced abrasive-grade silicon carbide in the United States during 2004 (table 1). This company also produced similar amounts of metallurgical-grade silicon carbide. A second company, in Hopkinsville, KY, produced a small quantity of silicon carbide, primarily intended for use in heat-resistant products rather than abrasives. U.S. silicon carbide production increased about 10% during 2004 to an estimated 35,000 t, and the value of production increased about 28% to an estimated \$21.5 million (table 2).

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 2004 included antislip abrasives, blasting abrasives, bonded abrasives, coated abrasives, polishing/buffing compounds, tumbling media, and wiresawing abrasives. The total value of silicon carbide consumed in the United States was estimated to be more than \$124 million in 2004.

Prices.—Based on information from industry sources and publications, the average value of abrasive-grade silicon carbide at the point of manufacture was estimated to be about \$614 per ton in 2004. The average value of total U.S. ground silicon carbide exports in 2004 was approximately \$890 per ton.

During 2004, imports from China accounted for 57% of total U.S. crude silicon carbide imports and had an average value of \$452 per ton; the average value of the remaining 43% of U.S. crude silicon carbide imports was \$389 per ton. The average value of silicon carbide grain imports was \$1,100 per ton; China accounted for 36% of such imports (table 5).

Foreign Trade.—During 2004, the United States exported crude silicon carbide to 19 countries and exported refined and ground silicon carbide to 30 countries. The total value of crude silicon carbide exports for 2004 increased by 13% to \$5.51 million from the total value for 2003 (table 6). Compared with 2003, exports of refined or ground silicon carbide decreased by about 3% to 10,200 t valued at \$9.05 million. Approximately 87% of the refined and ground material was shipped to Canada.

In 2004, the United States imported crude silicon carbide from 8 countries and imported ground and refined silicon carbide from 21 countries. Imports of crude silicon carbide increased by 18% during the year to 163,000 t valued at \$69.3 million (table 5). Imports of silicon carbide in ground or refined form increased 49% to 45,300 t valued at \$49.9 million. China accounted for 57% of the crude silicon carbide imports and 36% of the ground and refined silicon carbide. A large part of the imports from China reportedly included metallurgical-grade material.

Aluminum-Zirconium Oxide

During 2004, fused aluminum-zirconium oxide for abrasive applications, such as resin-bonded grinding wheels, was produced at one plant in the United States and one plant in Canada, both belonging to Norton Co. The USGS does not publish aluminum-zirconium oxide production data received from the producers to avoid disclosing company proprietary information.

Boron Carbide

Washington Mills was the only commercial producer of boron carbide in the United States during 2004. Boron carbide was used for grinding and lapping operations previously possible only with diamond dust; it also was molded to form highly wear-resistant products, such as pressure blast nozzle liners and extrusion dies. Domestic production data for boron carbide are concealed to avoid disclosing company proprietary data.

Metallic Abrasives

Production.—Data on U.S. production and shipments of metallic abrasives were based on a survey of domestic producers conducted by the USGS. Survey data were collected from 13 companies operating 15 plants in the United States and accounted for all the domestic production (table 3).

Steel shot and grit accounted for almost all of the metallic abrasives produced domestically (table 4). U.S. production of steel shot and grit in 2004 increased by 1% compared with that of 2003; the average value was \$455 per ton. Seven companies reported production of cut wire shot in 2004, and most of that was cut from carbon steel wire and stainless steel wire. Other products reported included shot cut from aluminum, copper, and zinc wire. One company reported production of steel nuggets, a wrought carbon steel blast media with properties similar to steel shot.

Consumption.—Metal abrasives are used primarily as loose particles propelled at high velocities for blast cleaning or to improve the properties of metal surfaces; approximately 75% of the abrasives is employed in cleaning operations. Principal consumers include foundries, machine tool industries, metalworking plants (particularly those supporting the automotive and aircraft industries), and steel manufacturers.

During 2004, total sales of all steel shot and grit by U.S. producers decreased by 5% compared with shipments in the preceding year to about 200,000 t, with an average value of \$464 per ton sold or used.

Prices.—The USGS compiles survey data on the value of production and shipments, but it does not collect price data. Values of production and shipments reported by metallic abrasive producers in 2004 are listed in table 4. Average values of steel shot and grit ranged from \$0.38 to \$0.74 per kilogram. Average values of cut wire shot ranged from \$4.22 to \$5.85 per kilogram for aluminum wire shot and from \$2.39 to \$4.74 per kilogram for stainless steel wire shot. Average unit values for metallic abrasives traded by the United States during 2004 were as follows: exports, \$0.78 per kilogram, and imports, \$0.60 per kilogram.

Foreign Trade.—U.S. exports of metallic abrasives increased by 21% during the year to 26,500 t valued at \$20.6 million (table 6). Canada and Mexico received 94% of the U.S. exports of metallic abrasives in 2004.

During 2004, the United States imported metallic abrasives from 12 countries and exported metallic abrasives to 36 countries. Domestic imports decreased by 4% in 2004 to 15,900 t valued at \$9.52 million (table 5). About 71% of the imports came from Canada; most of the remaining imports, in descending order, were shipped from South Africa, Germany, and, Romania.

Outlook

Abrasives markets closely follow economic and technological trends and are greatly influenced by activity in the manufacturing sector in the United States. This is particularly true of manufacturing activities in the aerospace, automotive, furniture, housing, and steel industries. Even though abrasives markets are linked to these end-use manufacturing sectors, growth in these sectors may not necessarily lead to an increase in abrasives consumption. Improved technology in these manufacturing sectors is resulting in surface quality that requires less grinding and finishing operations that use abrasives (O'Driscoll, 2003). Cheaper imports and higher domestic costs will continue to challenge U.S. producers of fused aluminum oxide and silicon carbide to maintain market share. Competition from developing nations, especially China, will probably lead to further decreases in domestic output. China has become a dominant force in both fused aluminum oxide and silicon carbide in recent years. This has changed the makeup of the manufactured abrasives market. Lower priced Chinese exports have displaced and will continue to displace manufactured abrasive produced in Europe and North America (Gasser, 2002). The traditional suppliers among the Western industrialized nations are expected to continue consolidating and contracting.

Emerging suppliers of fused aluminum oxide and silicon carbide in China, Eastern Europe, India, the Republic of Korea, and South America will continue to increase their prominence in world markets. Further success for these suppliers, particularly in such major markets as Japan, the United States, and Western Europe, will depend on their ability to provide higher grades of material and levels of supply reliability while maintaining lower prices. Energy costs, furnace size, quality-control systems, and the availability of essential mineral inputs will be the dominant factors influencing the competitive stance of these suppliers (O'Driscoll, 1997; Zhilun, 1997; Lunghofer and Wolfe, 1998).

The housing construction sector in North America will continue to have a significant indirect influence on demand for manufactured abrasives because of the large volumes of manufactured abrasives used in cutting and finishing wallboard and timber. The aerospace and automotive manufacturing sectors also will continue to be significant indirect influences on demand for manufactured abrasives used by metalworking operations supporting those sectors.

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TABLE 1
CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS IN 2004

Company	Plant location	Product
Exolon Co., The	Hennepin, IL	Silicon carbide.
Norton Co.	Huntsville, AL	Fused aluminum oxide (high-purity) and aluminum-zirconium oxide.
Do.	Chippewa, Ontario, Canada	Aluminum-zirconium oxide.
Washington Mills Electro Minerals Corp.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
Do.	Niagara Falls, NY	Fused aluminum oxide (high-purity) and boron carbide.

TABLE 2
ESTIMATED PRODUCTION OF CRUDE SILICON CARBIDE AND FUSED ALUMINUM
OXIDE IN THE UNITED STATES AND CANADA^{1, 2}

Product	2003		2004	
	Quantity ^{3, 4} (metric tons)	Value ³ (thousands)	Quantity ^{3, 4} (metric tons)	Value ³ (thousands)
Aluminum oxide, regular, abrasives ⁵	20,000	\$5,800	20,000	\$6,500
Silicon carbide ⁶	35,000	18,500	35,000	21,500

¹Data are rounded to no more than three significant digits.

²Yearend stock data are withheld to avoid disclosing company proprietary data.

³Owing to rounding, data do not match total quarterly Mineral Industry Surveys estimated data.

⁴Quantities are rounded to the nearest 5,000 tons to avoid disclosing company proprietary data.

⁵Regular grade normally accounts for about 48% of total output, and high-purity material accounts for the remainder.

⁶Approximately one-half of the quantity and value consists of material for metallurgical and other nonabrasive applications.

TABLE 3
U.S. PRODUCERS OF METALLIC ABRASIVES IN 2004

Company	Plant location	Product (shot and/or grit)
Abrasive Materials Inc.	Hillsdale, MI	Cut wire.
Chesapeake Specialty Products, Inc.	Baltimore, MD	Steel.
Ervin Industries, Inc.	Adrian, MI	Do.
Do.	Butler, PA	Do.
Do.	do.	Do.
Frohn North America, Inc.	Austell, GA	Cut wire.
Marwas Steel Co.	Scottdale, PA	Do.
Metaltec Steel Abrasives Co.	Canton, MI	Steel.
National Metal Abrasive Inc.	Wadsworth, OH	Do.
Peerless Metal Powders & Abrasive Co., Inc.	Detroit, MI	Steel and steel nuggets.
Pellets, Inc.	Tonawanda, NY	Cut wire.
Platt Brothers, Inc., The	Waterbury, CT	Do.
Premier Shot Co.	Cleveland, OH	Do.
U.S. Filter Abrasive Materials, Inc.	Hillsdale, MI	Do.
Wheelabrator Abrasives, Inc.	Bedford, VA	Steel.

TABLE 4
PRODUCTION AND SHIPMENTS FOR METALLIC ABRASIVES IN THE
UNITED STATES, BY PRODUCT¹

Product	Production		Shipments ²	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2003:				
Steel shot and grit	192,000	\$86,200	210,000	\$97,900
Cut wire shot and other ^c	1,220	4,630	1,180	4,960
Total	193,000	90,800	211,000	103,000
2004:				
Steel shot and grit	193,000	87,800	200,000	92,700
Cut wire shot and other ^c	1,260	4,250	1,310	4,750
Total	194,000	92,000	201,000	97,400

^cEstimated.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes reported exports.

TABLE 5
U.S. IMPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
ABRASIVES, BY COUNTRY AND TYPE¹

Country	2003		2004	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide:				
Crude:				
Canada	19,100	\$6,850	20,100	\$8,140
China	89,000	18,500	144,000	35,300
Venezuela	14,000	5,150	15,100	6,280
Other	1,170	1,000	1,290	580
Total	123,000	31,600	181,000	50,300
Ground and refined:				
Austria	4,840	6,500	6,470	8,660
Brazil	7,430	4,490	8,980	5,610
Canada	1,210	1,330	5,010	3,590
China	12,100	3,550	2,810	1,090
France	1,770	2,560	2,150	3,360
Germany	7,940	11,000	10,400	13,100
Hungary	2,340	1,870	3,340	2,510
Italy	1,650	1,350	4,580	3,220
Slovenia	493	269	717	363
South Africa	--	--	960	448
United Kingdom	522	1,630	976	2,890
Venezuela	--	--	3,990	1,430
Other	447 ^r	872 ^r	863	1,490
Total	40,700	35,400	51,200	47,800
Silicon carbide:				
Crude:				
Brazil	--	--	12,000	5,520
Canada	207	125	20	10
China	103,000	32,000	92,800	41,900
Germany	2	15	--	--
Netherlands	12,100	3,270	17,100	5,220
Norway	1,730	5,150	670	1,800
Romania	--	--	13,500	4,550
Russia	8,060	2,870	6,030	2,430
Venezuela	13,500	4,620	21,100	7,880
Total	139,000	48,100	163,000	69,300
Ground and refined:				
Brazil	7,220	5,170	11,600	7,870
China	13,200	7,980	16,100	11,800
Germany	1,010	3,880	1,350	5,160
Japan	1,070	4,730	1,320	6,360
Mexico	601	967	467	736
Norway	1,050	3,510	3,270	10,500
Philippines	1,330	987	2,190	1,490
Russia	1,100	557	3,940	1,980
Venezuela	3,700	2,220	3,490	2,070
Vietnam	--	--	1,170	793
Other	197	812	450	1,170
Total	30,500	30,800	45,300	49,900
Metallic abrasives:				
Canada	10,500	4,530	11,300	5,660
France	60	29	119	55
Germany	2,030	2,780	1,230	1,490
Japan	400	534	97	137

See footnotes at end of table.

TABLE 5—Continued
U.S. IMPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
ABRASIVES, BY COUNTRY AND TYPE¹

Country	2003		2004	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Metallic abrasives—Continued:				
Romania	806	758	787	993
South Africa	2,330	717	2,040	856
Other	357 ^r	311 ^r	326	325
Total	16,500	9,650	15,900	9,520

^rRevised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Customs value.

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
ABRASIVES, BY COUNTRY AND TYPE¹

Country	2003		2004	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Aluminum oxide, crude:				
Brazil	387	\$1,640	587	\$3,100
Belgium	380	769	425	722
Canada	2,920	3,530	3,280	4,010
China	47	214	104	1,220
Germany	3,900	13,700	4,610	15,100
India	118	421	163	610
Japan	1,150	5,250	1,270	6,920
Korea, Republic of	539	2,540	921	4,320
Mexico	1,700	2,520	2,200	2,850
Netherlands	209	500	18	84
United Kingdom	128	1,510	78	447
Other	297 ^r	1,970 ^r	285	1,850
Total	11,800	34,600	13,900	41,200
Silicon carbide:				
Crude:				
Brazil	18	185	54	410
Finland	(3)	4	34	99
Germany	91	192	33	89
Japan	343	1,690	1,070	2,440
Mexico	426	657	174	455
Norway	1,630	1,060	2,290	1,480
Other	277 ^r	1,110 ^r	55	537
Total	2,780	4,900	3,710	5,510
Ground and refined:				
Canada	8,550	5,010	8,830	5,690
China	4	7	17	52
Costa Rica	25	61	28	69
Finland	--	--	119	348
France	--	--	65	214
Germany	51	236	127	379
Korea, Republic of	59	178	29	138
Mexico	408	302	411	508
Norway	168	187	109	199
Russia	16	50	97	298
Spain	56	121	62	141
United Kingdom	105	156	195	319
Other	991 ^r	910 ^r	81	693
Total	10,400	7,220	10,200	9,050
Metallic abrasives:				
Australia	7	25	125	83
Bahamas, The	--	--	53	27
Canada	11,100	5,280	11,500	7,070
China	28	859	38	305
France	85	57	150	171
Indonesia	--	--	47	78
Italy	1	13	136	51
Japan	720	398	400	234
Mexico	9,480	6,980	13,500	11,300
Taiwan	122	114	154	176
United Kingdom	203	252	38	62
Venezuela	23	73	43	110

See footnotes at end of table.

TABLE 6—Continued
U.S. EXPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC
ABRASIVES, BY COUNTRY AND TYPE¹

Country	2003		2004	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Metallic abrasives—Continued:				
Vietnam	--	--	151	53
Other	214 ³	503 ³	207	902
Total	22,000	14,600	26,500	20,600

¹Revised. -- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Customs value.

³Less than ½ unit.

Source: U.S. Census Bureau.